THE RÖNTGEN-RAY DIAGNOSIS OF RENAL CALCULUS.

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THE development of the Röntgen technique marks the introduction of an exact method in the diagnosis of renal calculus. Formerly the diagnosis was made from the symptoms, pain and hæmorrhage, and confirmed or disproved by exploratory nephrotomy. The uncertainty of a diagnosis based upon symptoms is well illustrated by the experience of Henry Morris,[1] who reports forty-four nephrotomies for suspected stone in which no stone was found. It is well known that the symptoms, pain, hæmorrhage, pyuria, albuminuria, etc., belong to many other pathological conditions that may be present in the genito-urinary tract. When a stone is the cause of these symptoms, they arise as a result of the *functional disturbance or pathological changes* usually the result of infection in the kidney or ureter induced by the presence of a calculus and not by the stone *per se*. Since calculous formations give rise to symptoms only after pathological conditions have been brought about in the kidney, and since these changes bear no constant relation to the symptoms they produce, it often happens that extensive damage has been done to the kidney tissue before a symptomatic diagnosis can be made. Furthermore, the size and character of the stone bear no constant relation to the severity of the symptoms produced.

In 1899, Abbé [2] collected from the literature and tabulated twenty-five cases in which a positive diagnosis had been made by the X-ray and later confirmed by operation. To this list of twenty-five he added two cases of his own, making twenty-seven cases reported to that time. These twenty-seven cases are arranged by years as follows:

1896. McIntyr, of Glasgow, reported the first skiagraph of a stone taken in the body. Swain, of Bristol, reported a case.

1897. Gürl, Nüremberg; Fenwick, England; Thyne, Australia.

1898. Bevan, Chicago; McArthur, Chicago; Lauenstein, Germany; Alsburg, Germany; Martin, England; Taylor, England; Fenwick, England; Leonard, Philadelphia, eight cases; McBurney, New York; Abbé, New York, two cases.

1899. Wagner, Germany, two cases.

The percentage of error in the positive diagnosis of renal calculus by the Röntgen method is still undetermined, because of the variations in the methods used, the skill of the operators, and the differences in the patients whose cases have been reported. In 1898,[3] Lauenstein pointed out that up to that time only oxalate stones were thought to show, and cited a case in which a definite shadow of a stone consisting of calcium carbonate, chiefly with some calcium oxalate and uric acid, was obtained. In 1899,[4] Ringel, as a result of his work, laid down the following propositions:

1. By the Röntgen procedure only the rather infrequent oxalate stone shows with certainty.

2. The showing of other kinds of kidney stones which are more permeable for Röntgen rays succeeds only under certain favorable conditions, such as the presence of a very large stone or the presence of a very permeable patient.

3. The Röntgen ray is to be employed in every case of kidney stone as a means of diagnosis. Reliance is to be placed, however, only upon a positive result, while, from the failure to obtain a kidney stone shadow, the absence of a kidney stone should not be concluded.

Leonard,[5] in 1900 and 1901, reports the development of a technique by which he was enabled in the examination of 136 cases to positively diagnose kidney stone in 100, with a known error in but one case, and error of 1 per cent. He does not describe his technique beyond stating that he uses a self-regu-

lating tube of rather low vacuum with a large volume of X-rays. He[6] lays down the dictum that "Accuracy in the negative diagnosis can only be assured by the development of a technique capable of producing negatives in which a differentiation can be made between shadows of tissues less dense than the least dense calculus."

In a later report of 300 cases examined,[7] Leonard found calculi in 86, 28 per cent. Of these 86 cases 50 per cent. were in the ureter. In five of the 300 cases no stone was found at operation, though diagnosed positively by the X-ray. He gives no report as to the number of his positive diagnoses which later came to operation. Of those that *were* operated no stone was found in five cases. In all probability a large number of the cases diagnosed positively were not operated, and of these we do not know how many would have proven negative at operation. He concludes that "a negative diagnosis is as accurate as the positive," and that "operation is contraindicated when no shadow is shown by the X-ray unless some other pathological condition is present."

Kümmel and Rumpel[8] report a series of eighteen cases diagnosed positively by the X-ray, all of which were subsequently operated and stone extracted. The conclusions drawn from their work are as follows:

1. The exact diagnosis of kidney stone is to be made only by means of the Röntgen procedure.

2. The presence of a kidney stone, whether located in the kidney substance, the calices, or in the ureter, will be demonstrated upon the plate in every case by proper application of the Röntgen method.

3. The negative result of the Röntgen method after repeated attempts allows the exclusion of a calculus.

4. The demonstration of a stone shadow upon the Röntgen plate is not dependent upon the size and chemical composition of the calculus, but singly and alone upon the technique of the Röntgen operator.

5. A high degree of corpulence in the patient may render the demonstration of a calculus by the Röntgen method very difficult, but in general does not render it impossible.

6. In every case of nephrolithiasis it is advisable to employ the functional methods of investigation, since they show us by combined application (*a*) whether a disturbance of the whole kidney function exists or not, (*b*) whether we have to deal with a double-sided stone formation or other co-existing kidney disorder, or whether in the already existing disorder only one kidney is involved.

7. The result of the negative Röntgen investigation should be considered in connection with the condition of the clearness, concentration, and freezing-point of the urine obtained by means of the ureteral catheter.

In the eighteen cases tabulated by Rumpel,[9] two of the stones removed contained only triple phosphates. All the others consisted of mixtures in different proportions of calcium carbonate, calcium phosphate, calcium oxalate, and uric acid or urates. Five of the stones consisted largely of calcium oxalate, fourteen of calcium phosphate, and two of uric acid. Of the two stones consisting largely of uric acid, the composition of the first was a mixture of uric acid with calcium phosphate, and of the second a mixture of uric acid with calcium oxalate and calcium phosphate.

In twenty-seven cases of suspected kidney stone operated upon by Bevan at the Presbyterian Hospital during the last two and a half years, in which the writer has had the opportunity to employ the X-ray as a means of diagnosis, it has been possible to make a positive diagnosis of calculus in thirteen cases, a doubtful diagnosis in one case, and a negative diagnosis in thirteen cases. In the doubtful case operation revealed a single, thin, flat, oxalate stone the size and shape of a pumpkin seed lying well up under the last rib. More careful examination of the skiagraph in this case showed a rather vague shadow directly over the last rib. The failure was due perhaps more to an error in the interpretation of the skiagraph than to the skiagraph itself.

In the thirteen cases in which a negative diagnosis was made, the following conditions were found at operation: Tuberculosis, five cases; pyonephrosis, two cases; essential

renal hæmorrhage, two cases; cystonephrosis, one case; hydronephrosis, one case; polycystic kidney, one case; hypernephroma, one case.

The technique of the Röntgen method has been developed by the contributions of many workers both in this country and in Europe. Drs. O. Rumpel and Albers-Schönberg, of Germany, deserve special mention for having done much to develop the technique of the application of the Röntgen ray in the diagnosis of renal calculi. The essentials in the technique of skiagraphy as applied to the diagnosis of kidney stone may be briefly stated as follows:

The apparatus required consists of a coil capable of giving a heavy spark from ten to twenty inches in length; a tube with an adjustable vacuum capable of carrying a heavy secondary discharge from the coil and having a comparatively low vacuum; fresh plates thickly coated to secure the largest degree of absorption of the rays.

O. Rumpel [10] has pointed out the necessity of using soft tubes to secure the greatest possible degree of differentiation. He recommends "the longest possible exposure with the softest possible tube." The developer used must be one that permits long development with a minimum degree of fog. Glycin and edinol are to be especially recommended.

The patient to be examined should be given a cathartic some hours before the exposure is to be made, and he should also refrain from eating solid food for a few hours in order that the gastro-intestinal tract may be as empty as possible. Eppinger [11] has recommended dilating the colon when it is desired to examine the right kidney or the stomach if a skiagraph of the left kidney is desired. He states that by this dilatation the overlying omentum and intestines are pushed aside and an air-space interposed, thus making possible a more definite outline of the kidney region.

The patient having been prepared upon the table as shown in Fig. 1, a skiagraph is taken which includes the entire area from the pelvis to and including the last two ribs. The tube is enclosed in a tube-sheath which rests upon a wooden disk faced

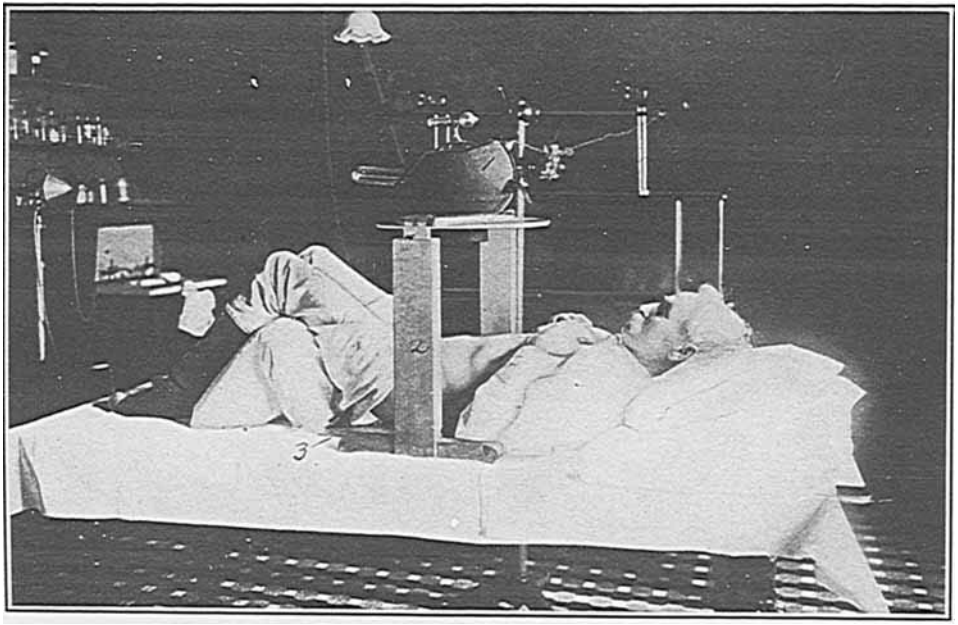

FIG. 1.—Apparatus arranged for taking a skiagraph of entire kidney region. 1. Tube in tube-holder. 2. Stand with circular top faced with lead plate one-sixteenth of an inch thick, having an opening three inches in diameter. 3. Steel plate one-eighth of an inch thick supporting sensitive plate.

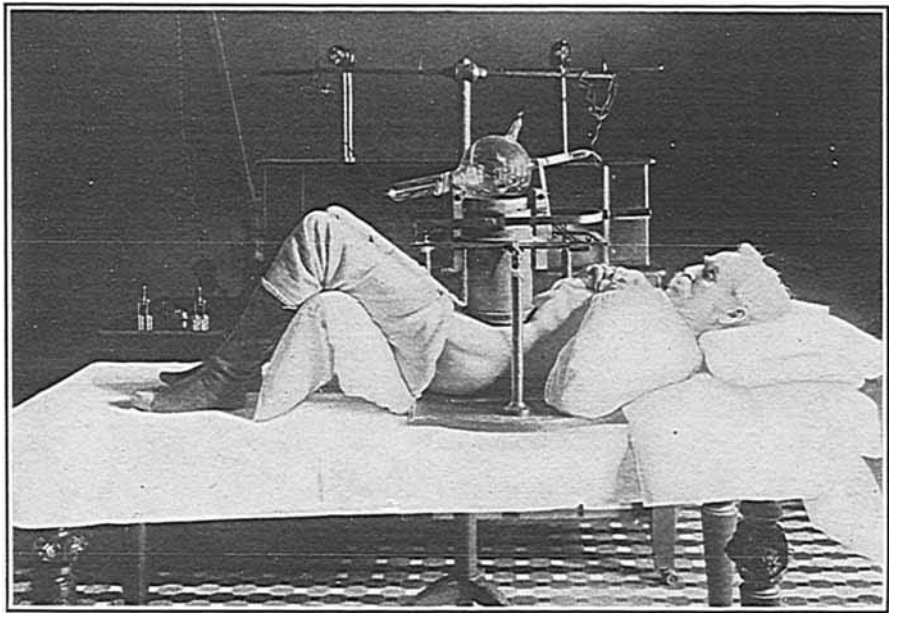

FIG. 2.—Lead cylinder apparatus of Albers-Schönberg.

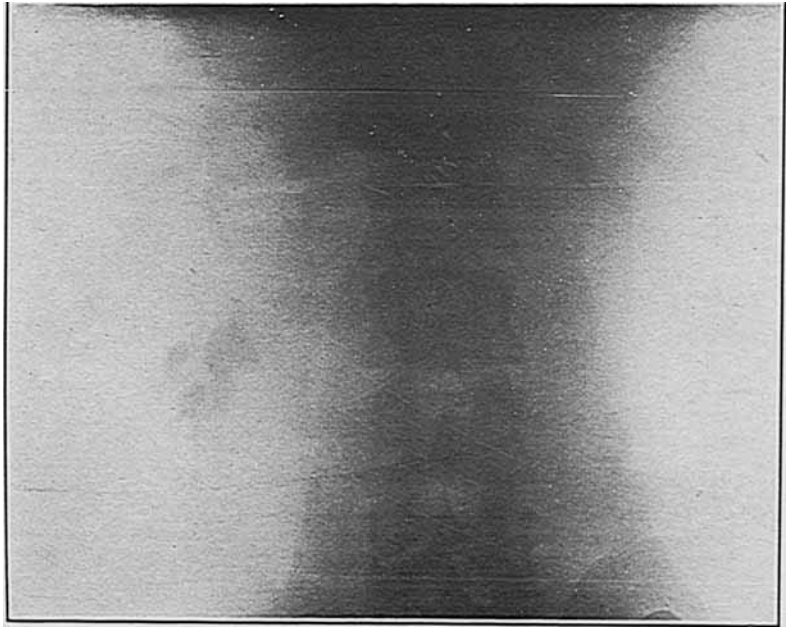

FIG. 3.—Four stones in left kidney.

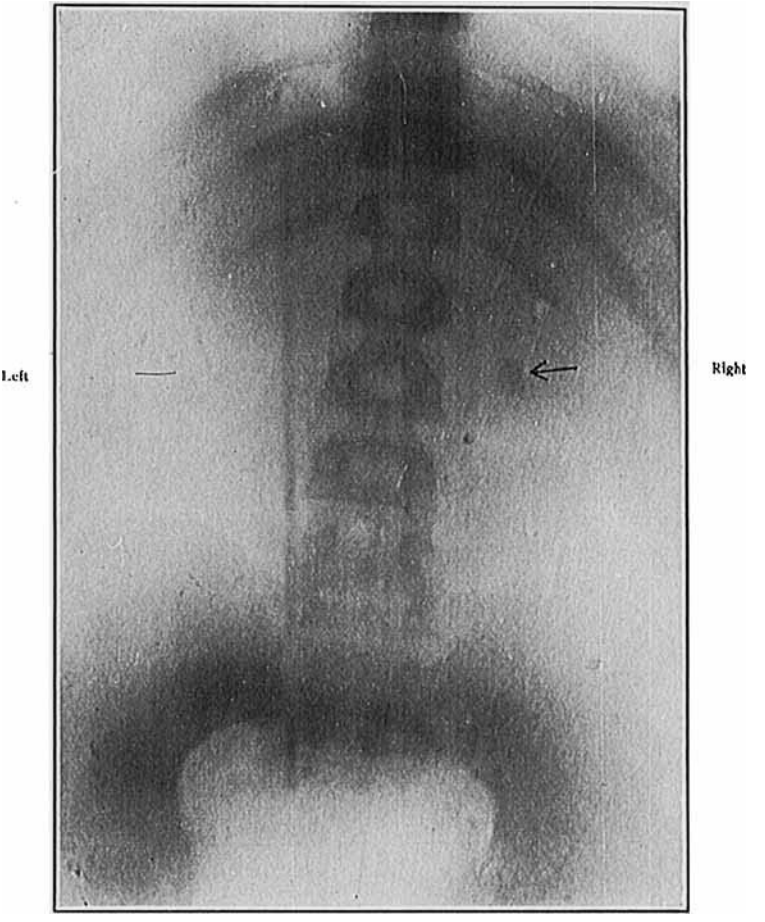

FIG. 4.—Single small stone in right kidney.

below with a lead plate having a circular opening three inches in diameter. This lead plate or diaphragm cuts off all the rays except those that come from the centre of the tube, thereby increasing the sharpness and clearness of the image. The patient is placed upon the table with thighs flexed upon the abdomen and head elevated so as to bring the back as closely in contact with the plate as possible. Hard pillows or sand-bags may be used to support the knees and head. The sensitive plate, supported by a heavy, flat, steel plate, is placed beneath the patient. The steel plate, besides giving support, obstructs any extraneous rays that may be given off by objects beneath the patient.

If it is desired to secure a still clearer picture of any part of the field, the apparatus devised by Albers-Schönberg, as shown in Fig. 2, is employed. Rumpel and Albers-Schönberg have shown that much of the failure in kidney-stone work is due to the diffusion of the rays in passing through the tissues, and that by the use of lead diaphragms or lead cylinders the extraneous rays may be cut off and much of the diffusion and consequent loss of detail avoided. The pressure of the heavy lead cylinder serves to diminish the respiratory motion of the abdominal organs, and also to materially reduce the thickness of the patient. Albers-Schönberg [12] lays down the following as the features that should characterize a good skiagraph of the kidney region:

1. It must show the transverse processes of the vertebræ.
2. It must show the last two ribs with structure.
3. It must enable one to differentiate the border of the psoas muscle from the quadratus lumborum.

When the lead cylinder is used, it is necessary to take two or three different negatives in order to cover the field of the kidney and ureter. This disadvantage is more than compensated by the gain in clearness of detail obtained by this method, especially in cases where doubtful or small shadows have been obtained in a general view of the entire region taken by the ordinary method.

In corpulent persons the pressure of the lead cylinder apparatus gives a considerable diminution in the thickness of

tissue to be penetrated by the rays, thereby shortening the exposure and diminishing the loss of detail by diffusion.

For diagnostic purposes, the plates themselves and not prints made from them should be relied upon as being of most service, since no print preserves the detail and delicate gradations of the original negative. The negatives should be examined by placing them in a window and observing them by reflected skylight or in an apparatus illuminated by incandescent electric light reflected from white surfaces. The use of an opera-glass, as suggested by Kümmel, is often very useful in the examination of a plate, because it limits the field of vision to the size of the plate when the observer stands six to ten feet away.

The Röntgen ray skilfully and properly applied makes it possible to make both positive and negative diagnoses of renal calculi with a very low percentage of error. It also gives much valuable information as to the size, number, and location of stones when present (Figs. 3 and 4), and enables the surgeon to approach an operation for nephrolithiasis with an exactness of knowledge not possible before the introduction of the X-ray as a means of diagnosis in diseases of the kidney.

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[10] Rumpel. Die Diagnose des Nierensteins.
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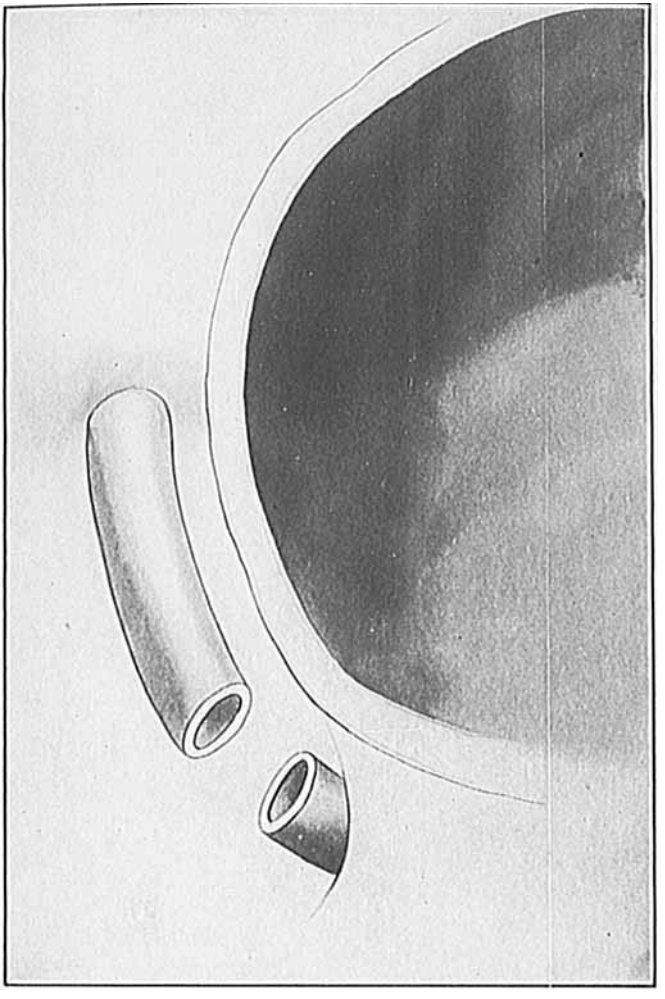

FIG. 1.—Ureter accidentally cut in vaginal hysterectomy. The upper cut end leads from the kidney, the lower end to the bladder. Semidiagrammatic.

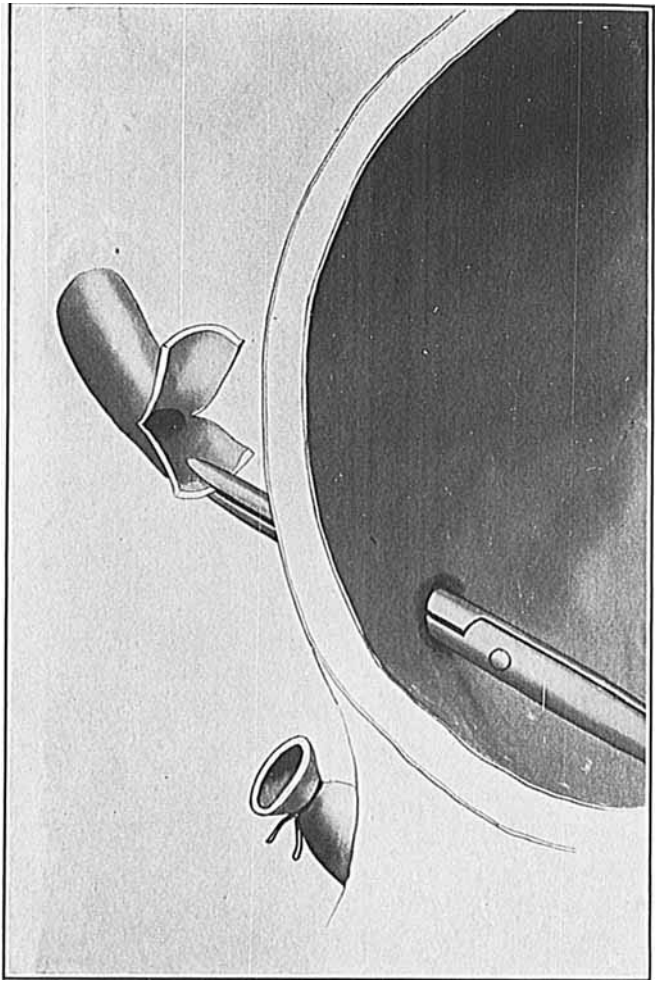

FIG. 2.—The upper cut end of the ureter split and in the grasp of a forceps which has previously made an opening from the interior to the exterior of the bladder by puncture. Semidiagrammatic.